SEPARATION OPTIMIZATION OF PALM KERNEL BY ITS' SPECIFIC GRAVITY AND FLOW RATE OF CLAY WATER BATH

RONALD ATORM ANAK JIMY

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Faculty of Chemical and Natural Resources Engineering

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ABSTRACT

In palm oil industry, there are two major product obtained from palm oil fruit, the palm oil and the palm oil kernel. Palm oil kernel is obtained from the Fresh Fruit Bunches after the pressing of the fruits. The leftover from the press was a mixture of fiber and nuts. After separating the fiber and nuts, these nuts were then cracked using ripple mill and a mixture of shell and kernel were produced. There are two ways to separate this two component, using hydrocyclone and clay water bath. This experiment will investigate the best ratio of water and kaolin to achieve the best separation of the shell and kernel. The parameters investigated were the Specific Gravity value of this kaolin mixture and the rotation speed of the cyclone. The clay bath principle works on the specific gravity of kernel of 1.07 and the shell of 1.17. The claybath will then be introduced with kaolin mixture using various value of Specific Gravity. The values investigated were 1.06, 1.08, 1.10, 1.12, 1.14, 1.16, 1.18 and 1.20. The kernel will started to float at Specific Gravity 1.08 and shell will start to float at Specific Gravity of 1.18. By drawing the graph of Separation Percentage versus Specific Gravity, the best Specific Gravity will then be able to be determined. After achieving the best separation Specific Gravity, flow rate of clay bath will then be tested. Flow rate of clay bath can be controlled using the pump. Various flow rate will be tested to see which produces the best separation ratio of kernel and shell. As a conclusion, the best specific gravity for clay bath was 1.16 and the flow rate that produces optimum separation was 70m^3/s.

ABSTRAK

Dalam industri minyak sawit, terdapat dua produk utama yang diperolehi dari buah sawit, iaitu minyak sawit dan buah isirong sawit. Buah isirong sawit boleh didapati dari buah tandan segar selepas proses pemerahan. Tinggalan dari proses tersebut akan meninggalkan hampas dan juga biji sawit. Biji sawit tersebut akan dipecahkan menggunakan pemecah biji lalu menghasilkan tempurung dan juga isirong sawit. Terdapat dua cara untuk memisahkan dua komponen tersebut, samada menggunakan hidrosiklon atau pemandi tanah liat. Eksperimen ini bertujuan untuk mencari peratusan pemisahan terbaik tempurung dan juga isirong. Parameter yang disiasat adalah Graviti Tentu (SG) campuran kaolin dan air dan juga kadar aliran air ke dalam pusaran pemandi tersebut. Pemandi tanah liat berfungsi atas dasar SG isirong 1.07 dan juga tempurung iaitu 1.17. Pemandi tersebut akan diuji dengan pelbagai nilai SG iaitu 1.06, 1.08, 1.10, 1.12, 1.14, 1.16, 1.18 dan juga 1.20. Selepas mendapatkan nilai SG yang optimum, kadar aliran akan diuji untuk mencari keadaan manakah pengasingan terbaik mapu dicapai. Kadar aliran ini akan dikawal dari pump pemandi tersebut. Sebagai konklusinya, SG yang terbaik adalah 1.16 manakala kadar aliran yang terbaik adalah 70m³/s.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Oil palm, is a unique crop where two distinct types of oil can be obtained. The crude palm oil can be obtain from the mesocarp of the fruit while the crude pal kernel oil can be obtained from the kernel of the oil palm. Both of these oils, which are mainly made up of triglycerides, are chemically and physically different from each other with palm oil high in palmitic acid (C16 fatty acid) and palm kernel oil high in lauric and myristic acids (C12 and C14 fatty acids respectively).

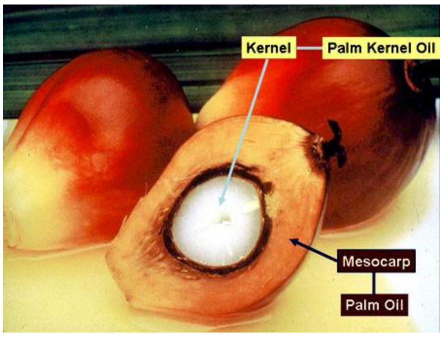

Figure 1.1 Oil Palm fruit


Figure 1.2 Oil Pam Nut

Palm kernel oil is very valuables because it contains lauric acid. Lauric acid is a useful fatty acid where it can be use to produce soaps, washing powders and personal care products. There are only two lauric oils, coconut oil (CNO) and palm kernel oil (PKO) (Oil World Annual, 2000) and they are called lauric because lauric acid is the major fatty acid in their composition at about 50%, while no other major oil contains more than about 1% (butter fat contains 3%).

To obtain the palm kernel oil, the nut of the oil palm must be obtained after the digestion process, which where the crude palm oil was obtained from, is completed. The nut will be cracked either at a ripple mill or the use of Rolek nut cracker. By cracking the nut, the shell and kernel is produced. This mixture of shell and nut will undergo a wet and dry separation process to separate the shell and the kernel. The dry separation will involved the use of winnowing column while the wet separation, clay water bath will be used. For this study, I will see how I can improve the separation of palm kernel and palm nut shell at the clay water bath.

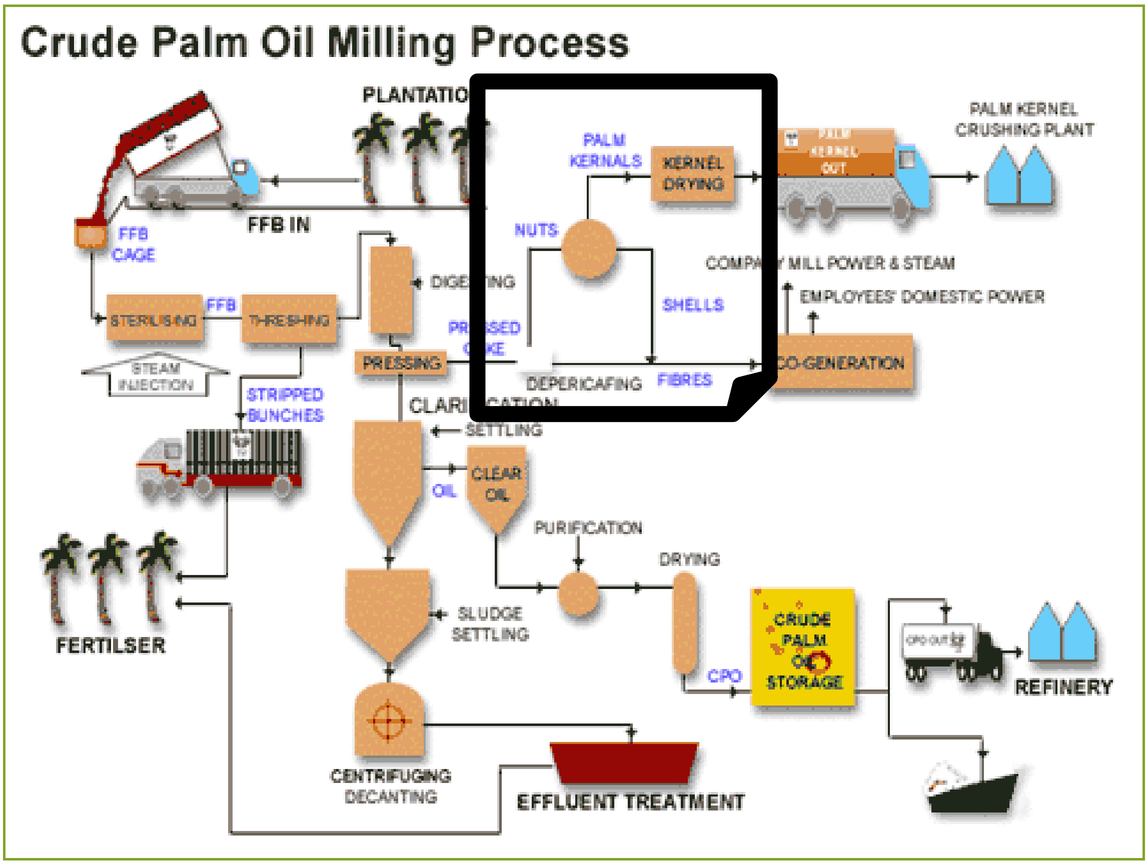

Figure 1.3 Palm Oil Mill Processes with Study Highlighted

1.2 OBJECTIVES

a) To enhance separation efficiency of the shell of the palm nut and palm kernel using clay-water bath.

b) To determine the optimum specific gravity of Kaolin (Aluminium Silicate) and flow rate of clay bath.

1.3 PROBLEM STATEMENT

Currently the industry are using two method for wet separation of palm kernel and palm nut shell. First, by using the hydrocyclone, and second is by using the clay water bath. Clay water bath uses kaolin as a material to be mixed with water so that when the mixture of kernel and shell is introduced, the kernel will float while the shell will sink. But the use of kaolin is expensive and it also produces a lot of waste after the separation was finished. Also, it is very hard to obtain the right ratio of water and kaolin where perfect separation can be obtain, since the current method used by the industry is trial and error where the kaolin will be introduced little by little and the specific gravity of this mixture will be tested. This will consume many working hours. If somehow the correct mixture is not obtained, the mixture of water and clay will have to be thrown away and this will produce unnecessary waste for the industry.

Therefore, this study is conducted to see the effectiveness of the separation method currently used by the industry. By doing this study, it was hoped that the usage of clay bath can be optimize in order to reduce the wastage of kaolin used in industry currently. By finding the optimum operational condition, it was hoped that some of the cost can be reduced in terms of using the kaolin and also prolonging the life of the clay bath itself. It is important to find a way to maximize the usage of kaolin due to its high cost and also find the best operating condition where maximum separation can be achieved at the clay bath.

1.4 RESEARCH SCOPE

In order to accomplish the objectives, the scope of this research is focusing on the criteria that are stated as below:-

i. To measure the efficiency of separation technique between palm kernel seed and palm nut shell using mixture of Kaolin and water.
ii. The determination the 'right' Kaolin and water mixture Specific Gravity (SG) inside the clay water bath using the hydrometer.

1.5 RATIONALE AND SIGNIFICANCE

The Rationale and Significance statements are as below:-

a) To help the industry reduce their cost of buying kaolin for use during the separation process.
b) To give the industry guidelines towards operating the clay bath optimally.
c) To cut down clay bath initialization time, since it is using trial and error to determine the correct specific gravity for separation

CHAPTER 2

LITERATURE REVIEW

2.1 Oil Palm

2.1.1 Introduction

The oil palm is an erect monoecious plant that produces separate male and female inflorences. The oil palm is cross pollinated and the main pollinating agent is the weevil, *Elaeidobius kamerunicus* Faust, a type of insect. Harvesting can be done after 24-30 months after planting where each palm tree can produce up to 15 Fresh Fruit Bunch(FFB) per year. Each fruit weight an average of 20 kg each.

Each FFB will contain around 1000 to 1200 fruitlets; each fruitlets consists of a fibrous mesocarp layer, the endocarp (shell) which kotaind the kernel. Present day planting materials are capable of producing 39 tonnes of FFB per ha and 8.6 tonnes of palm oil and actual yields from good commercial plantings are about 30 tonnes FFB per ha with5.0 to 6.0 tonnes oil [Henson. 1990]. In Malaysia, the average FFB yeield in 2001 was 19.14 tonnes while productivity was 3.66 tonnes per ha.

2.1.2 Types Of Oil Palm

The most common palm oil used in the industries come from the *Dura*, *Tenera* and *Pisifera* which can be differentiate according to the endocarp and medium mesocarp content (35% - 55% fruit weight). The *tenera* race has a 0.5 – 3mm thick endocarp and high mesocarp content of 60-95% and the *pisifera* palms have no endocarp and about 95% mesocarp [Latiff, 2000]

Traditionally, breeding of oil palm has focused on yield improvement, in terms of FFB and oil content, slow height increment, oil quality and disease tolerance. Currently, the industry is has placed emphasis on the production of the following types of planting materials to meet industry and market needs (Rajanaidu *et al*, 2000):

- Development of dwarf palms (PSI type) – to reduce the palm height increment and significantly extend the economic cropping cycle.

- Breeding for high unsaturated oil (High iodine value) (PS2 type) – to produce materials with higher proportions of unsaturated fatty acids by crosses with high iodine value Nigerian *duras* and *E guineensis* x *E. oleifera* hybrids.

- Breeding for high lauric oil (PS3 type) – using high yielding Nigerian *dura* palms with
high kernel contents

- Breeding for high carotenoid content (PS4 type) – using selected Nigerian *duras* and
pisiferas as well as hybridisation with *E. oleifera*.

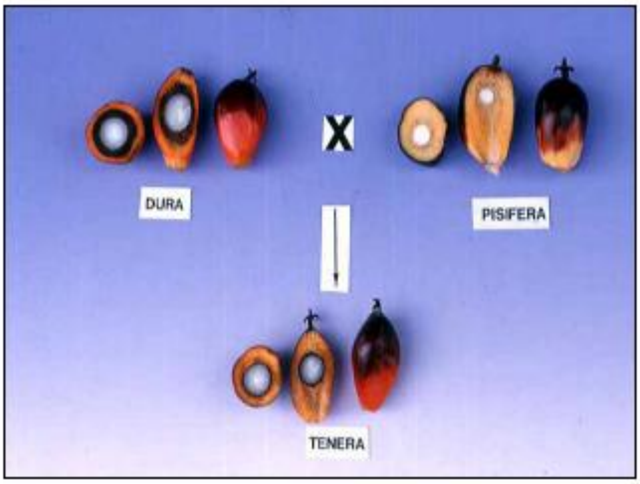

Figure 2.1 Different type of palm oil .

As current DxP planting materials derived from seeds have a high level of variation, several companies undertook research on production of clonal palms in the 1980s. This research was based on the premise that yields can be increased by about 30% with clones derived from elite palms in a DxP population (Hardon *et al*, 1987). However, commercial production of clones was hampered by the discovery of abnormal flowering behaviour (Corley *et al*, 1986) and the research effort was diverted to overcoming the occurrence of abnormalities in palm clones. A few companies have planted clonal palms on a commercial and one of them, PPB Oil Palms Berhad had obtained very encouraging results. Their earliest clonal planting had produced a 31% increase in FFB per ha and 54% improvement in oil yield compared to conventional DxP materials during the initial seven years of production (Siburat *et al*, 2002).

The palm oil industry has also embarked on genetic engineering work; the primary strategy of the Malaysian Palm Oil Board (MPOB) is to produce transgenic oil palm with high oleic oil content (Cheah, 2000, Yusof, 2001). Although MPOB has made significant progress in this endeavour, it many take many years before genetically-modified (GM) palms become available for commercial planting. Estimates for commercialisation ranged from 15 years (Corley, 1999) to 30-40 years (Pushparajah, 2001). The latest projection indicates that transgenic high oleic acid palms could be available for field testing from 2007-2010 and commercial planting could commence around 2015 (Ravigadevi *et. al.*, 2002).

2.2 PALM OIL MILLS

2.2.1 Activities In Palm Oil Mills

Below are the main activities that summarized the production of FFB:

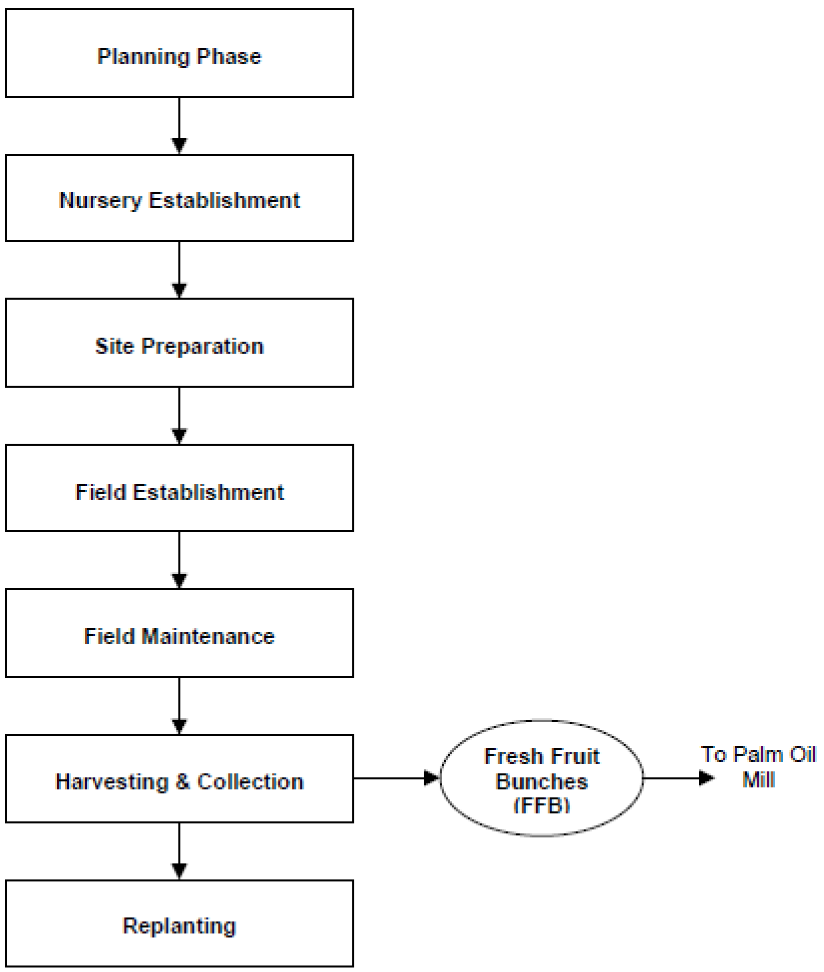

Figure 2.2 Palm Oil Milling Activities

FFB can be harvested after field planting was commenced between 24 to 30 months, which depend on soil type and agronomic and management inputs. Harvesting was done manually using tools such as chisel and sickle. To transport the FFB to the palm oil mill, workers are equipped with mechanical help such as tractors which usuaaly installed with a grabber to facilitate with obtaining the FFB and also transporting them to the mill.

Figure 2.3 (a) and (b); (a) using sickle to get the FFB; (b) grabbing the FFB using a grabber.

After harvesting, the fresh fruit bunch must be processed as soon as possible to prevent the rise of free fatty acid which will affect the quality of crude palm oil(CPO). Palm oil mills are usually situated near a plantation so that it can easily obtain the oil palm to be sent to the palm oil mills for processing. As of 2001, there are a total of 352 palm oil mills in Malaysia, where 70% are located at the Peninsular Malaysia [Teoh, C.H., for WWF Switzerland, November 2002].

Region	Oil Mills		Refineries		Crushing Factories	
	No	Capacity[1]	No	Capacity[2]	No	Capacity[3]
P. Malaysia	244	45,373,720	38	10,952,900	30	3,254,600
Sabah	89	18,750,600	9	4,596,500	8	1,057,500
Sarawak	19	3,620,400				
Malaysia	352	67,744,720	47	15,549,400	38	4,312,100

Source: MPOB   Capacity: 1. Tonnes FFB / year
2. Tonnes CPO / year
3. Tonnes Palm Kernel /year

Table 2.1 No. of oil mills, refineries and crushing factories in malaysia

2.3 PALM OIL PROCESSING

2.3.1 Processing Fresh Fruit Bunch (FFB)

The palm oil milling process starts by extracting the fruit of the oil palm to obtain the CPO. The process begins with the sterilization of Fresh Fruit Bunch(FFB) using steam up to 3 bars to stop the formation of Free Fatty Acid (FFA). The FFB then will be sent to a rotating drum thresher to separate the fruit with the Empty Fruit Bunch (EFB). The fruit will be then later sent to the digester where it will be cook using steam to loosen the oil-bearing mesocarp from the nuts and thus break the oil cells present in the mesocarp [Teoh, C.H., for WWF Switzerland, November 2002].

The digested mash will then be later pressed to extract the oil using screw pressers. The press cake is then delivered to the kernel plant by conveyer to be further processed.

The oil from the press will be diluted and pump to vertical clarifier tanks. Impurities from these oil will be removed and dried using vacuum. This cleaned oil will then be later stored, ready for delivery. The sludge from the clarifier sediment is fed into the bowl centrifuges to recover more oil. The recovered oil is then recycled to the clarifier while the sludge mixture, referred to as Palm Oil Mill Effluent(POME) is then treated at the effluent treatment plant (ETP).

For the press cake, it will be delivered to the decipericarper where the fibre and nuts are separated. The fibre will be use to fire steam boilers whereas the nuts will be cracked and the shell and kernel will be separated by using a winnower and a mixture of hydro cyclone and clay water bath.

The diagram below will clarify more on the production of palm oil process.

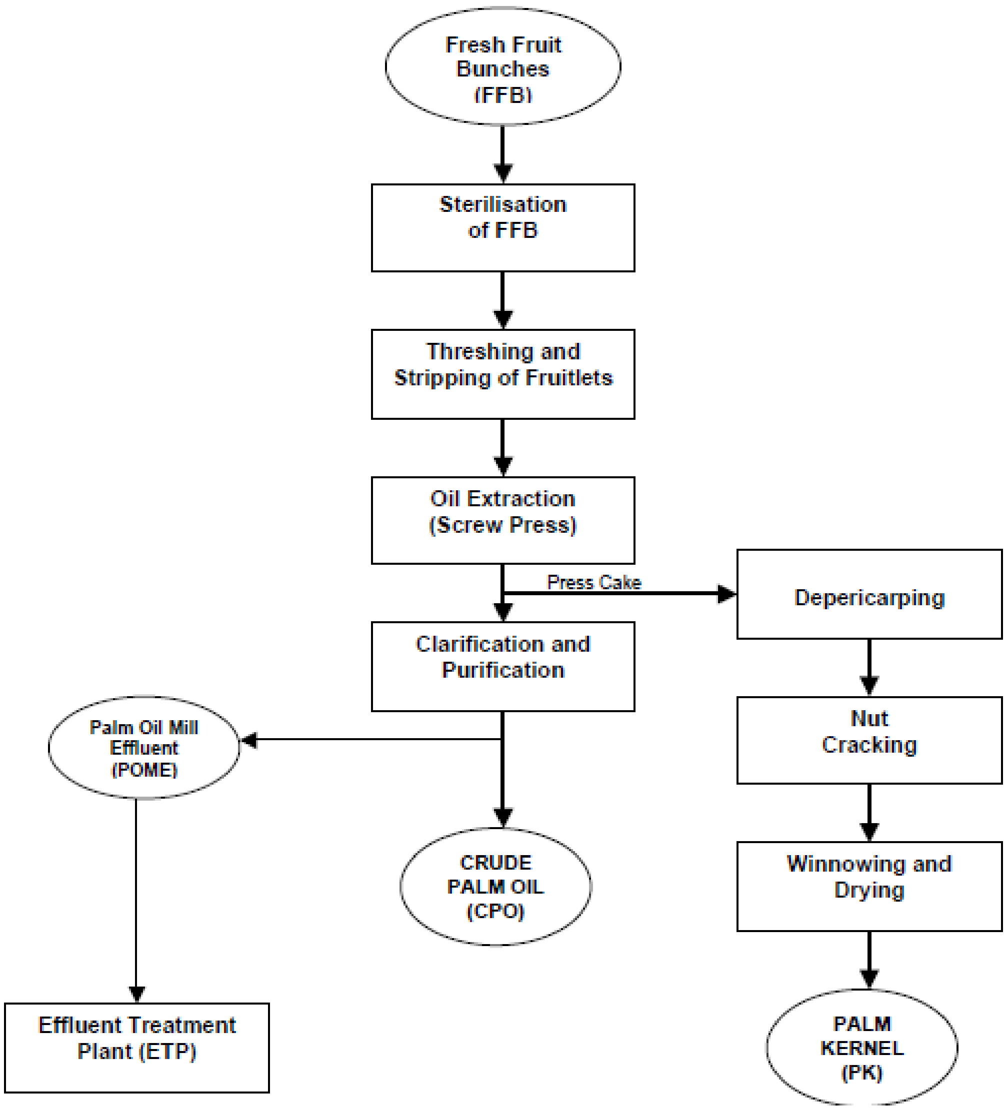

Figure 2.4 Processing involves FFB

2.3.2 PROCESSING PALM KERNEL

Palm kernel is a byproduct of processes in a palm oil mill. It consist about 45-48 % of the palm nut, while on a wet basis the kernels contain 47-50% by weight of oil [Thin, S.T., and Pek, K.T., February 1985]. The general composition of a palm kernel is shown in the table below.

Typical Composition of Malaysian Palm Kernels (% by Weight)

Oil content	49.0
Protein (N × 6.25)	8.3
Crude fiber	8.1
Moisture content	6.5
Ash	2.0
Carbohydrate	26.1
	100.0

Table 2.2 Palm kernel composition

Palm kernel is often obtain in a conventional kernel recovery plant to be used for obtaining palm kernel oil. The usual method used is by combining a dry and wet separation method [MPOB TT No. 427, June 2009]. The palm seed will be crushed and the cracked mixture, consists of kernels and shells will be separated by a winnowing column and partly through a hydro-cyclone or clay bath system.

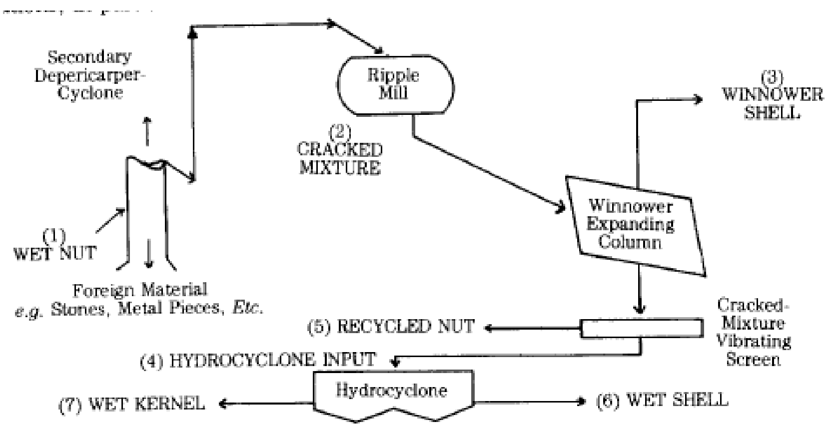

Figure 2.5 Process undergone by palm oil nuts.

The wet system, which is using the clay water bath is less environmental friendly because of the high volume of waste it produces [MPOB TT No. 427, June 2009].

To obtain the palm kernel though, the nut of the fruit must be crushed first. This is usually achived by the means of using the Rolek nut cracker [Rohaya et. al., August 2002]. This nut cracker is the joint invention between Malaysian Palm Oil Board and also Hur Far Engineering Works Sdn Bhd. The reason behind this invention is to obtain a maximum cracking efficiency of palm nuts and also to promote better separation of shell and kernel through the production of uniform and small size shell.

The main concept of Rolek's design involves two types of cracker rods, namely rotary and stator rods. Both of this rods will interact to break the nuts in the cracking compartments. There are variation for the thickness of the sleeve which can provide maximum interaction and dynamic force between nuts and the rods to ensure clean cracking and less loss of kernel. The next figure will show the design and the working principle of Rolek.

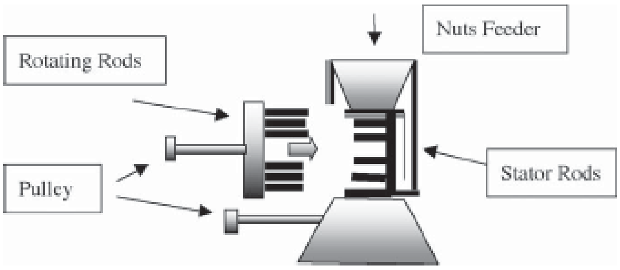

Figure 2.6 the components of The Rolek Nut Cracker

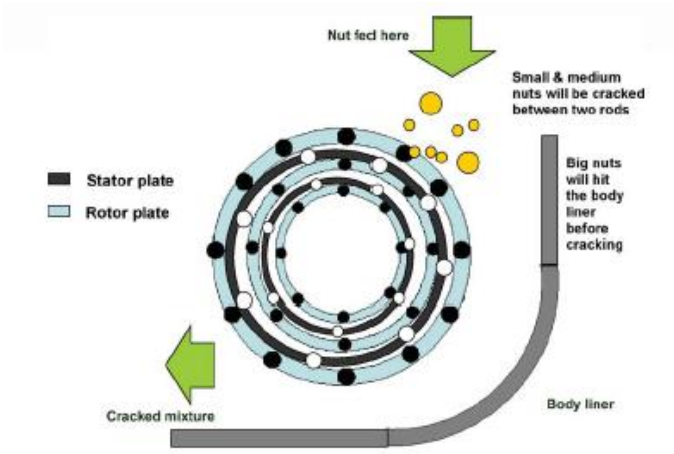

Figure 2.7 The working principle of the Rolek nut Cracker

To measure the efficiency of the Rolek machine, the formula below is being use to indicate the cracking efficiency:

$$\text{Cracking eff, } \eta = \frac{\text{wt of sample} - (\text{wt of uncracked} + \text{half cracked nuts})}{\text{Sample wt}} \times 100\%$$

An analysis was done [Rohaya et. al., August 2002] in three mill in Malaysia to determine the efficiencies of this machine. From the analysis, it is determined that whole kernel that was obtained ranged from 25 – 50 %, while broken kernel was ranged between 8% - 10%. For cracking performance and half cracked nut analysis, it is summarized in the table below:

Parameter, %	Rolek			Typical ripple mill*
	Targeted performance	Mill A - *tenera*	Mills B & C - *dura*	
Whole kernel	25 - 50	40 – 50	25 – 35	30 – 32
Broken kernel	< 10	8 – 10	9 – 10	15 – 25
Uncracked nut	< 1.5	0.5 – 1.0	0.5 – 1.0	1.0 – 2.0
Half cracked nut	< 2.0	1.0 – 2.0	1.0 – 1.5	1.0 – 3.0
Shell (small & uniform)	-	35 - 55	30 – 45	-
Big shell	-	-	20 – 30	-
Cracking efficiency	> 98	98 – 99	98	98 (pulverized kernel)
KER, %	-	6.5 – 7.2	6.3 – 7.0	5.5 - 6.0

Notes: *Courtesy and source: Rohaya, M H and Osman, A (2000). The quality of Malaysian palm kernel: effect of shell and broken kernel on the quality of final products.

Table 2.3 Performance of Rolek Nut Cracker in selected mills.

From this cracking, different sizes of kernel is obtained. Usually the cracked nuts will produce shell and kernel mixture which must be separated using the winnowing column and also the clay water bath. Below are the pictures of palm shell and palm kernel after the Rolek machine cracked the nuts:

(a)

(b)

(c)

(d)

Figure 2.8 (a), (b). (c) and (d); Palm oil kernel and nuts after crushing of palm oil nuts.